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RESPONSE OF SEVERAL VERTICAL ARRAY PROCESSORS

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TELEDYNE, INC.

Under

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RESPONSE OF SEVERAL VERTICAL ARRAY PROCESSORS

SEISMIC DATA LABORATORY REPORT NO. 212

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ABSTRACT

Several of the simplest vertical array processors were evaluated by means of frequency-wavenumber spectral analysis. The processors analyzed were beamed sum, multichannel deghost, and the fan filter. Adequate responses were obtained in the specified signal pass-band for all of the processors. Considerable differences between the processors were observed in the dead-band, especially at low wavenumbers corresponding to surface wave components in the noise. The best dead-band response was obtained for the fan filter using a spacing with uphole time between instruments of .1 seconds from the top to the bottom of the well.

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PROCEDURE

The SDL frequency-wavenumber analysis program VFKSPTRM (1966) was used to calculate the response of several simple processors for vertical arrays. The impulse responses of the filters as applied to each channel was subjected to frequency-wavenumber analysis. This implies an equal and simultaneous impulsive input to each channel.

Each processor involves a beamed sum of P-waves based on normal moveout times for vertical compressional waves. The multichannel deghoster and fan filter are followed by other operations designed to remove signal distortion or improve the dead-band response of the processor. The multichannel deghoster estimates the signal waveform at the surface without regard to correlated background noise. The fan filter (1967) ideally passes waves between a specified pass-band of limiting vertical phase velocities and rejects energy outside of the band.

We examined several vertical array geometries. These are specified by uphole times based on the arrival of the up-going vertical compressional wave at each instrument in the array subtracted from the arrival time at the surface. A vertical phase velocity of 6 km/sec was used for the f-k analysis.

The following table correlates the array geometry, type of processor and figure number. Each figure shows the relative power response in the f-k plane.

TABLE 1

Fig. No.	Processor	No. of Channels	Uphole times (sec.)	Frequency Bandpass (cps)	Velocity Bandpass (km/sec)
1	Beamed sum	7	.05,.15,.25,.35,.45,.55,.65	All Pass	0
2	Beamed sum	7	.05,.15,.25,.35,.45,.55,.65	.4 - 3.0	0
3	Beamed sum	7	.00,.15,.25,.35,.45,.55,.65	All Pass	0
4	Beamed sum	6	.15,.25,.35,.45,.55,.65	All Pass	0
5	Beamed sum	6	.05,.15,.25,.35,.45,.55	All Pass	0
6	Beamed sum	6	.05,.15,.25,.35,.45,.55	0.4 - 3.0	0
7	MCdeG	6	.05,.15,.25,.35,.45,.55	All Pass	0
8	MCdeG	6	.15,.25,.35,.45,.55,.65	All Pass	0
9	MCdeG	6	.05,.15,.25,.35,.45,.55	0.4 - 3.0	0
10	Fan Filter	6	.05,.15,.25,.35,.45,.55	All Pass	3.0-9.0
11	Fan Filter	6	.05,.15,.25,.35,.45,.55	0.4 - 3.0	3.0-9.0
12	Fan Filter	7	.05,.15,.25,.35,.45,.55,.65	0.4 - 3.0	3.0-9.0
13	Fan Filter	6	.15,.25,.35,.45,.55,.65	All Pass	3.0-9.0
14	Fan Filter	6	.05,.15,.25,.35,.45,.55	All Pass	4.5-7.5

RESULTS

Comparing Figure 2 and Figure 6 we see that an 18% increase in the length of the vertical array makes only slight improvement in the array response. An array with maximum uphole time of .55 sec. with 6 instruments provides an adequate response in the signal band with the power to discriminate body waves at frequencies above .7 cps.

Figures 4, 8, and 12 show the array response for equally spaced instruments placed in the lower 2/3 of the well. The apparent resolving power is inadequate between 1.0 and 1.3 cps for all of the processors analyzed. The fan filter appears to have the desired pass-band response with better dead-band rejection than the beamed sum and multichannel deghoster.

REFERENCES

McCowan, D.W., Finite Fourier transformer theory and its application to the computation of convolutions, correlations, and spectra, Seismic Data Laboratory Report No. 168 (Revised) Teledyne, Alexandria, Va., 1966.

Treitel, S., Shanks, J.L., Frasier, C.W., Some aspects of fan filtering, Geophysics, Vol. 32, n. 5, 1967.

TABLE 2

Symbols For the F-K Spectral Mapping

DB	Symbol
0-1	0
1.001 - 3	0
6-9	6
12-15	2
18-21	8
24-27	.

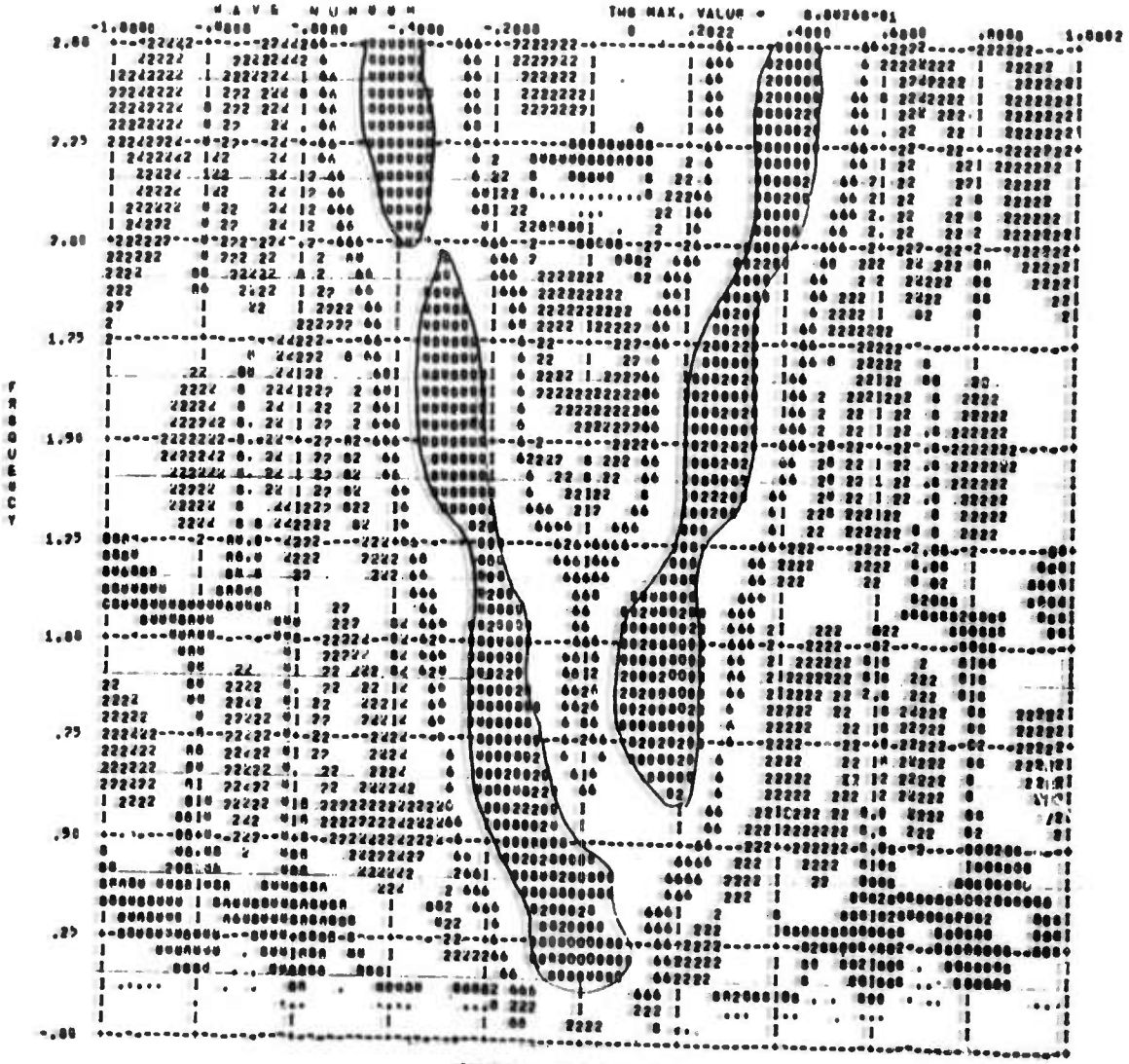
VFKSPTRH

SEISMOGRAM NO. = 3 NO. OF CHANNEL = 7

SAMPLING RATE = 00.00 STARTING POINT = 000 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
DW1	1.00	.382
DW2	1.00	.908
DW3	1.00	1.000
DW4	1.00	0.100
DW5	1.00	2.700
DW6	1.00	2.000
DW7	1.00	2.000



ARRAY RESPONSE

Figure 1. Beamed Sum

VERSPTHM

SMOOTHING NO. =	3	NO. OF CHANNEL =	7
SAMPLING RATE = 20.00	STARTING POINT = 500	TOTAL POINTS =	199

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
CH1	1.00	.300
CH2	1.00	.900
CH3	1.00	1.500
CH4	1.00	2.100
CH5	1.00	2.700
CH6	1.00	3.300
CH7	1.00	3.900

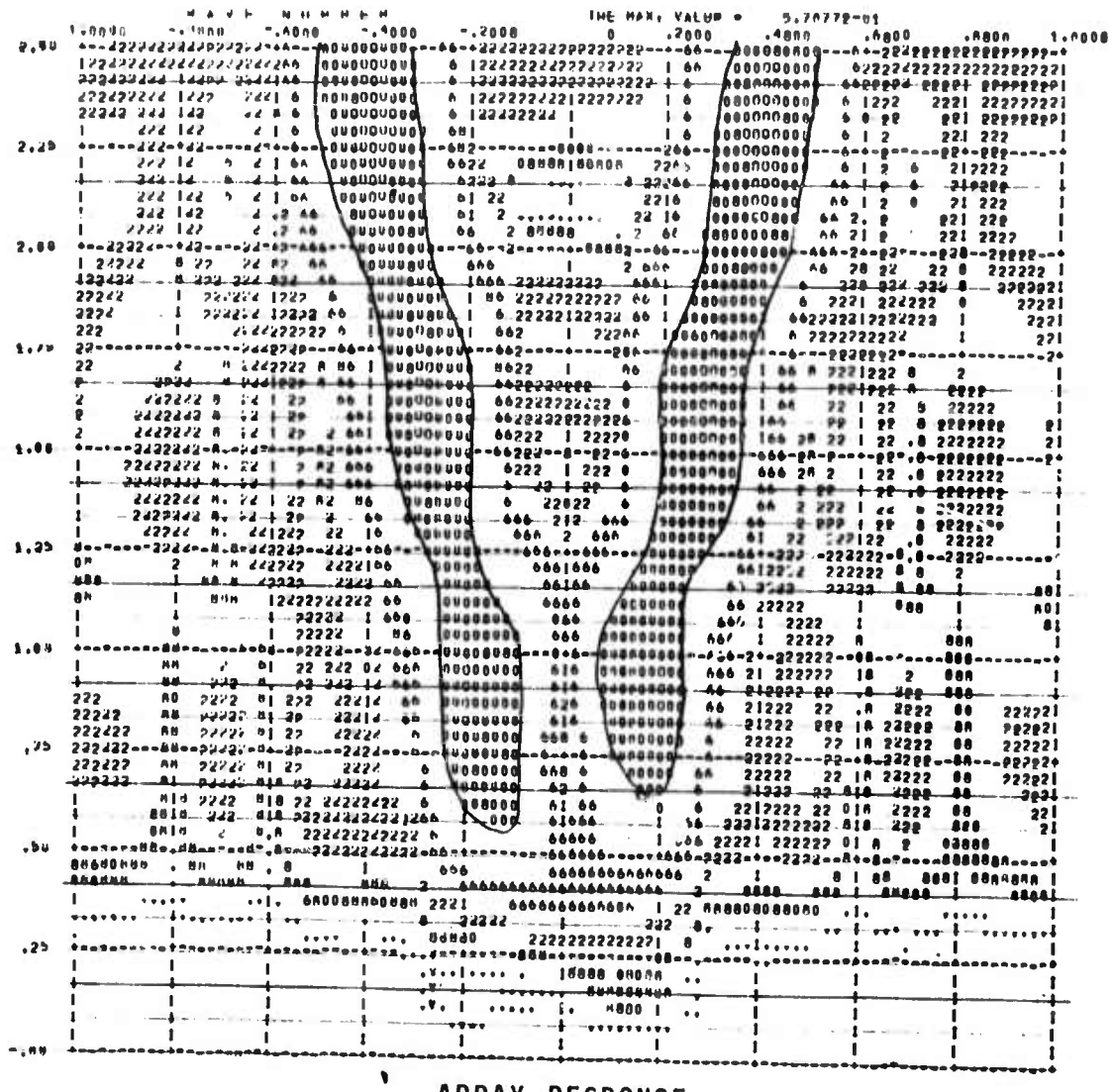


Figure 2. Beamed Sum

VFKSPTRM

SEISMOGRAM NO. = 5 NO. OF CHANNEL = 7

SAMPLING RATE = 20.00 STARTING POINT = 500 TOTAL POINTS = 198

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
DW1	1.00	.000
DW2	1.00	.000
DW3	1.00	1.500
DW4	1.00	2.100
DW5	1.00	2.700
DW6	1.00	3.300
DW7	1.00	3.900

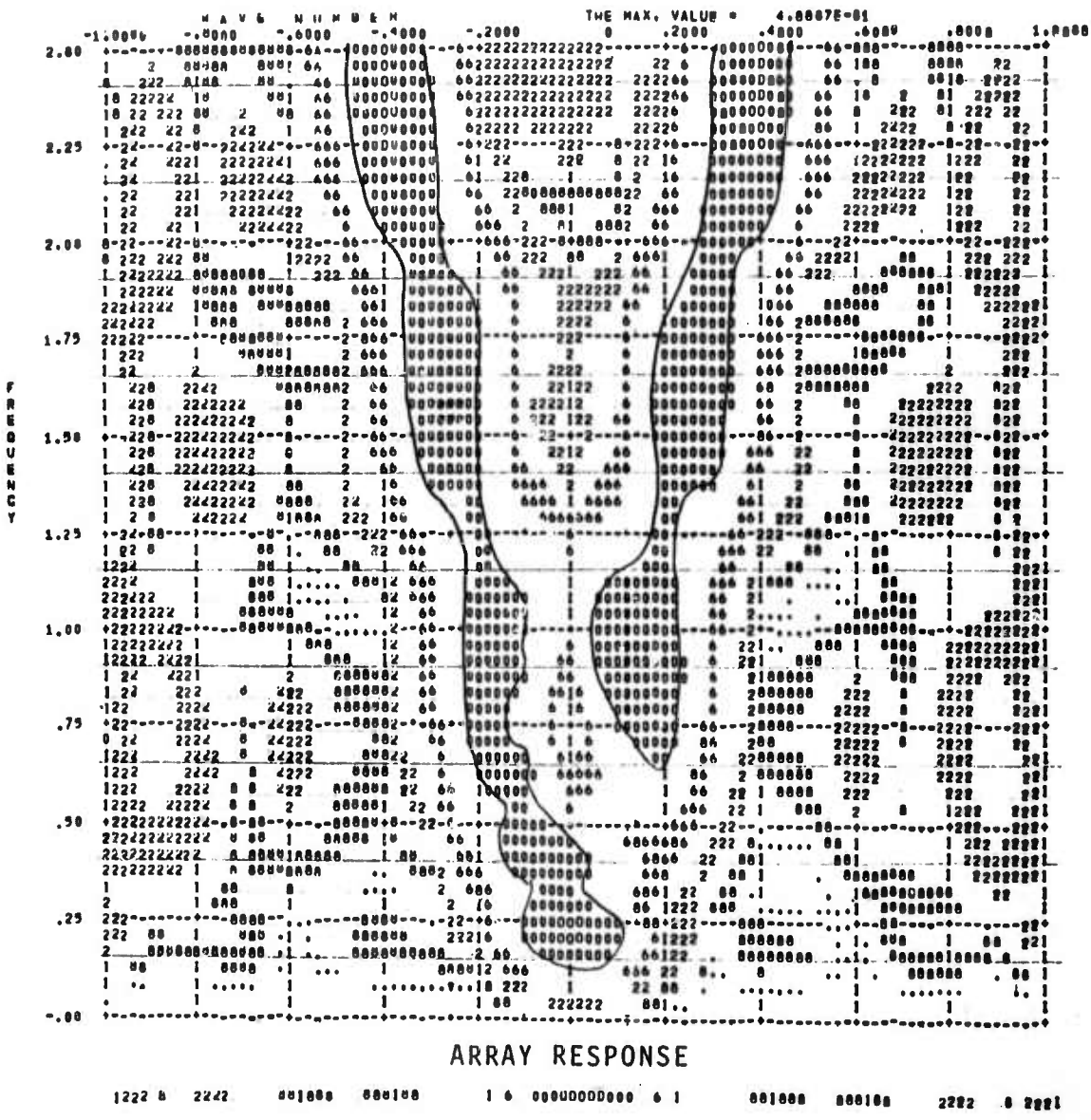


Figure 3. Beamed Sum

VERDPTHM

SEISMOGRAM NO. = 2 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 000 TOTAL POINTS = 120

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
DW1	1.00	.900
DW2	1.00	1.500
DW3	1.00	0.100
DW4	1.00	2.700
DW5	1.00	3.300
DW6	1.00	3.900

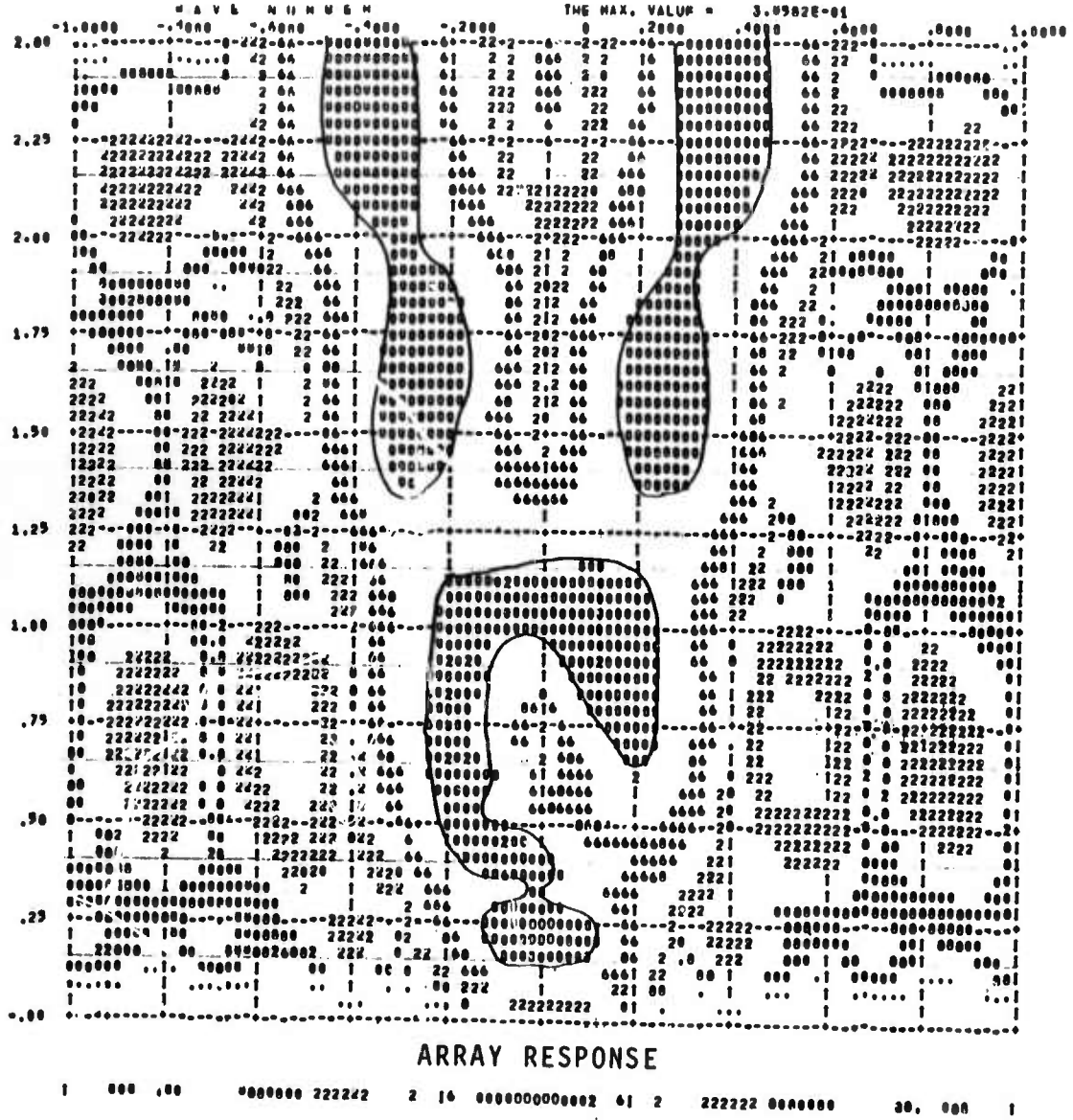


Figure 4. Beamed Sum

VFKSPTRM

SEISMOGRAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 0A0 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
DW1	1.00	.300
DW2	1.00	.900
DW3	1.00	1.500
DW4	1.00	2.100
DW5	1.00	2.700
DW6	1.00	3.300

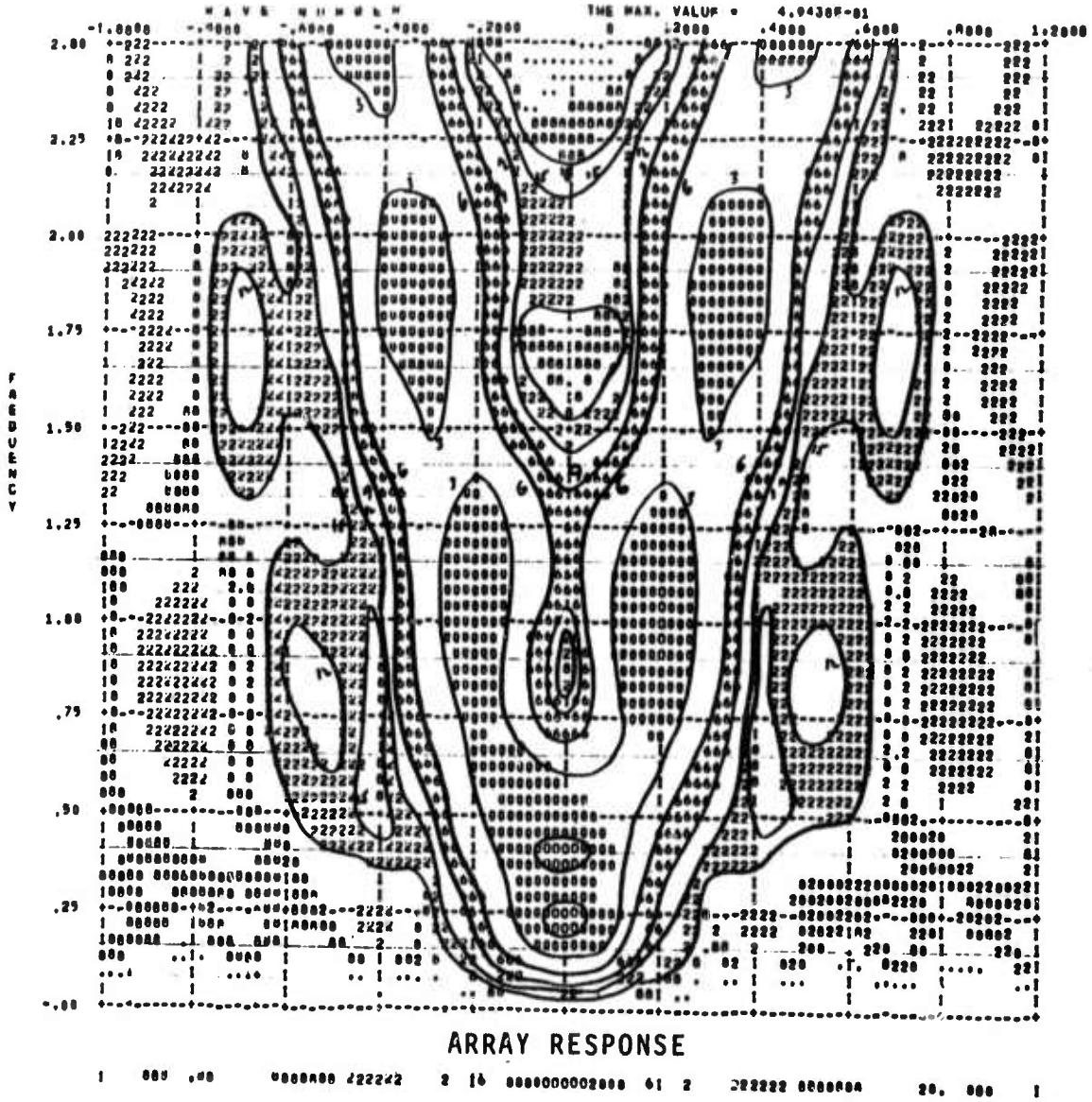


Figure 5. Beamed Sum

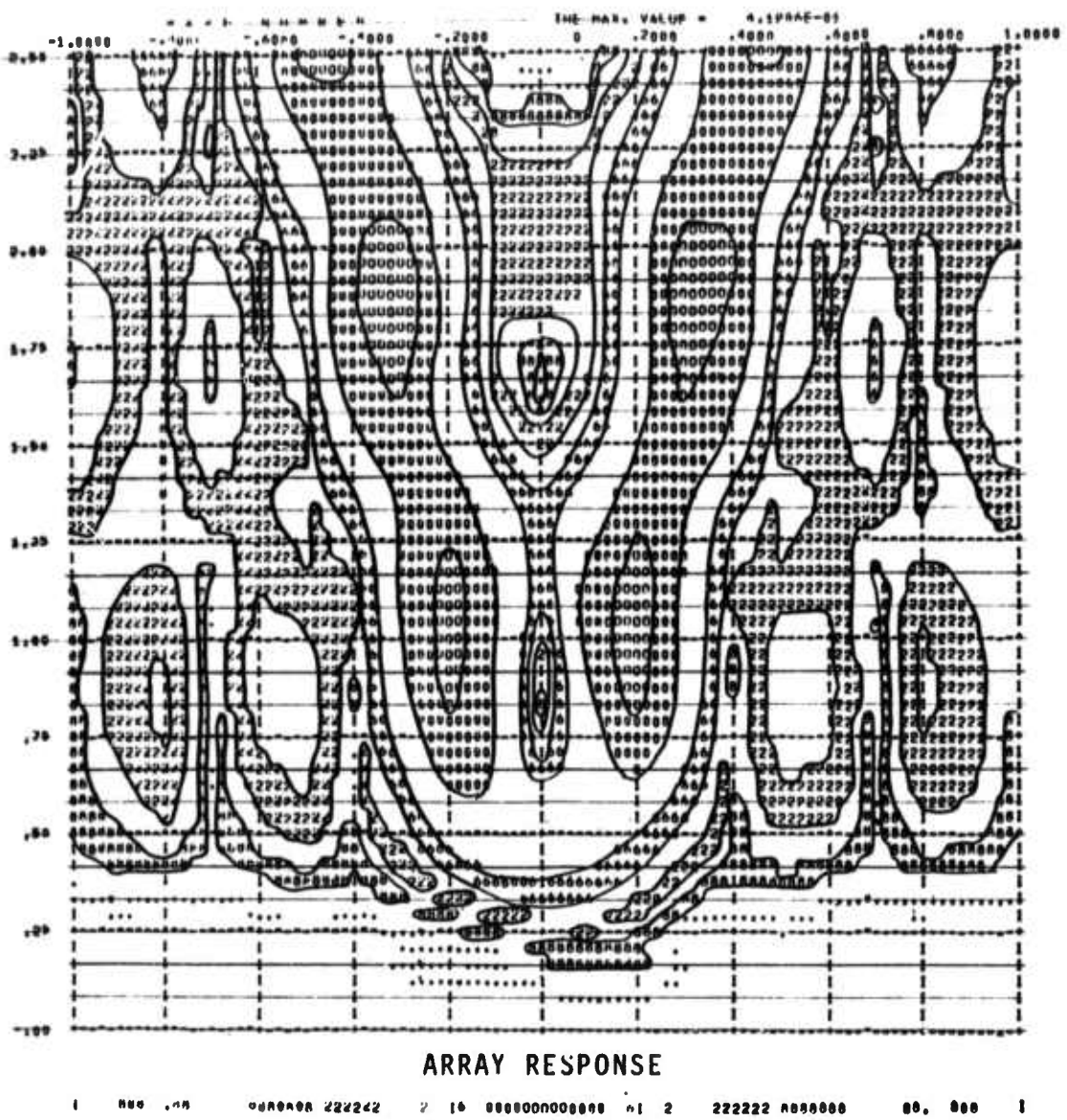


Figure 6. Beamed Sum

VFKBPTHM

BEINHOHAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 500 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
DW1	1.00	.300
DW2	1.00	.900
DW3	1.00	1.800
DW4	1.00	2.100
DW5	1.00	2.700
DW6	1.00	3.300

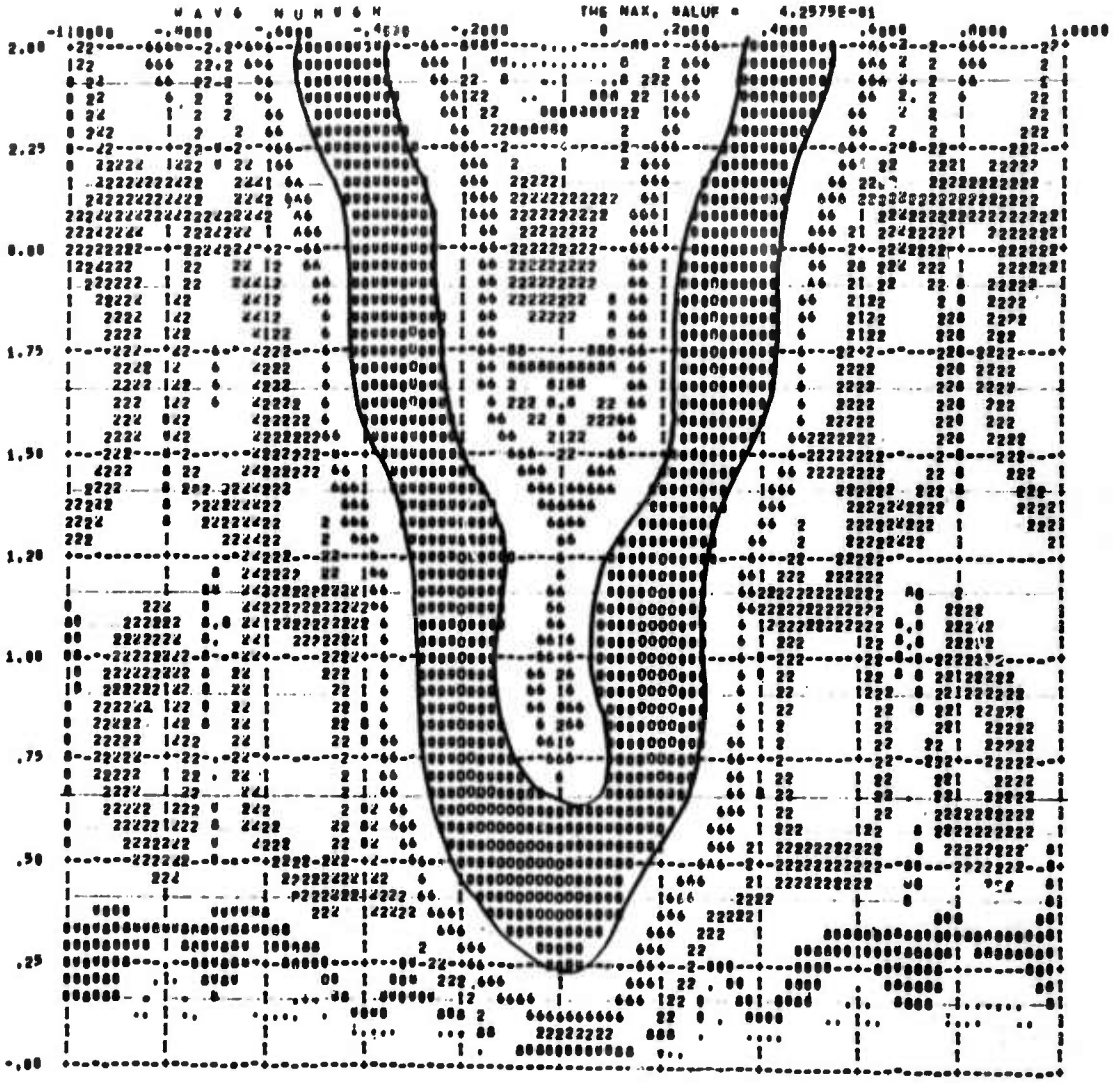


Figure 7. MCdeG

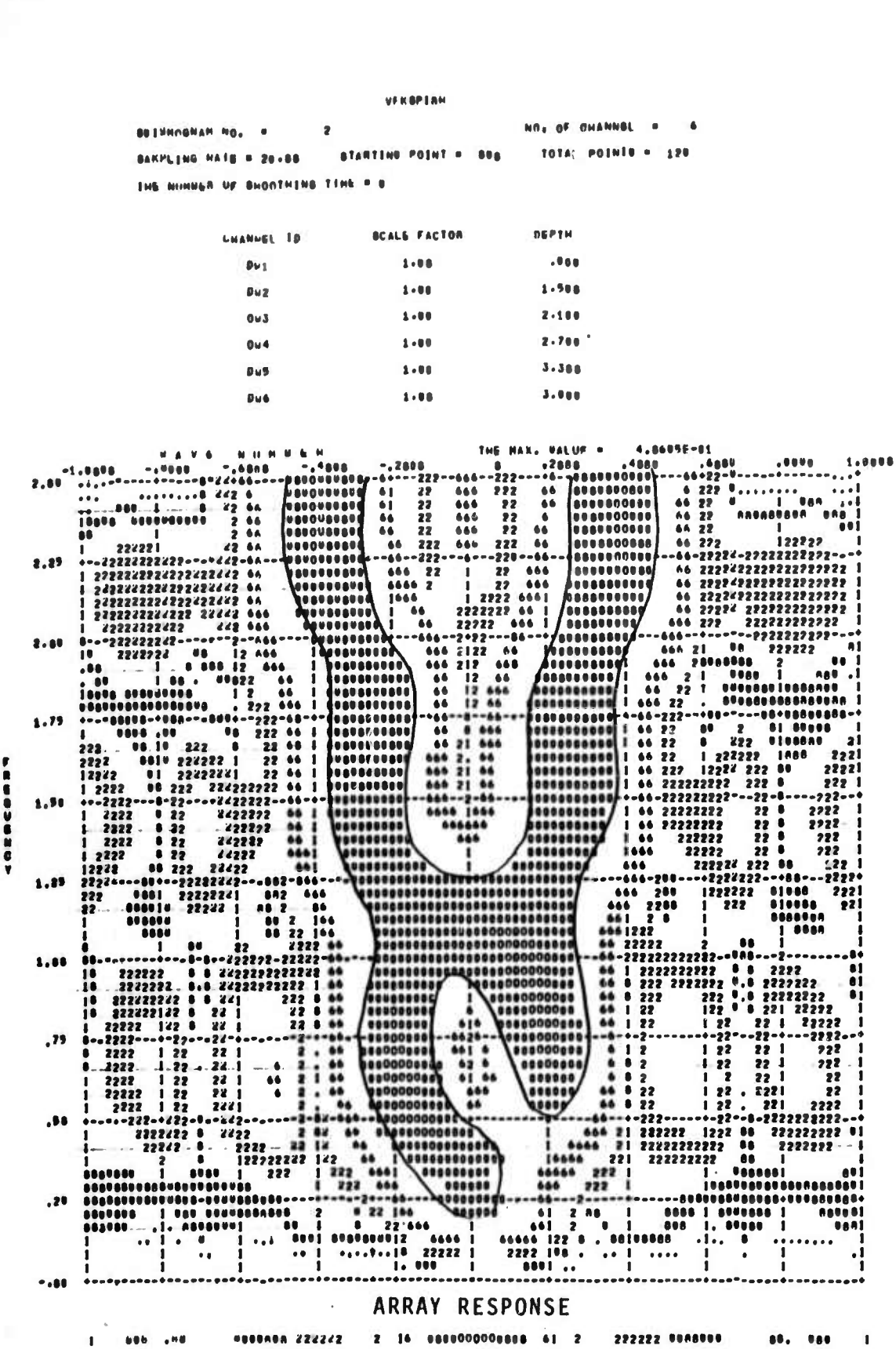


Figure 8. MCdeG

VERSION

BEISHONGHAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 BIGHTING POINT = 960 TOTAL POINTS = 120

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
Du1	1.00	.300
Du2	1.00	.900
Du3	1.00	1.500
Du4	1.00	2.100
Du5	1.00	2.700
Du6	1.00	3.300

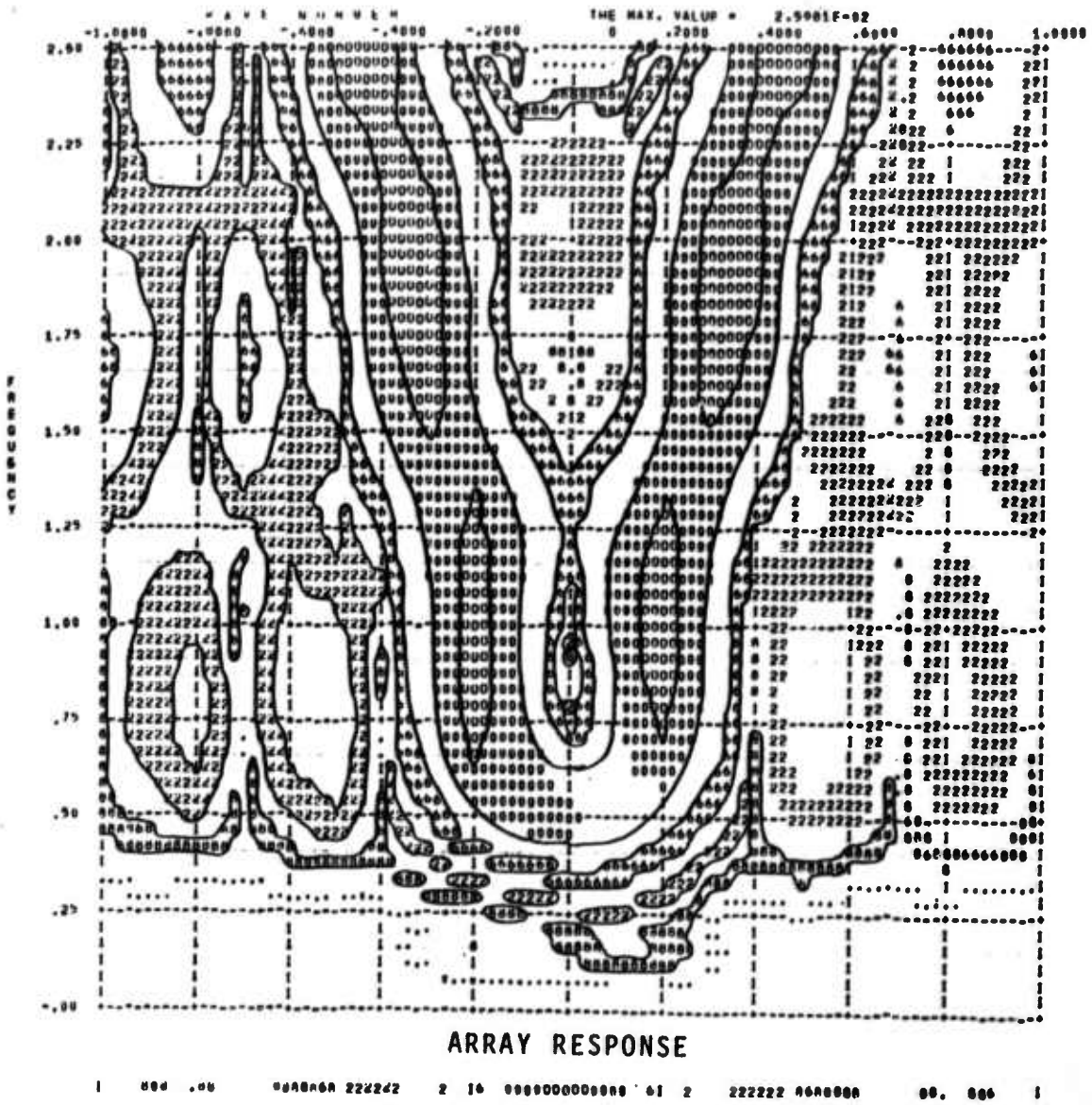


Figure 9. MCdeG

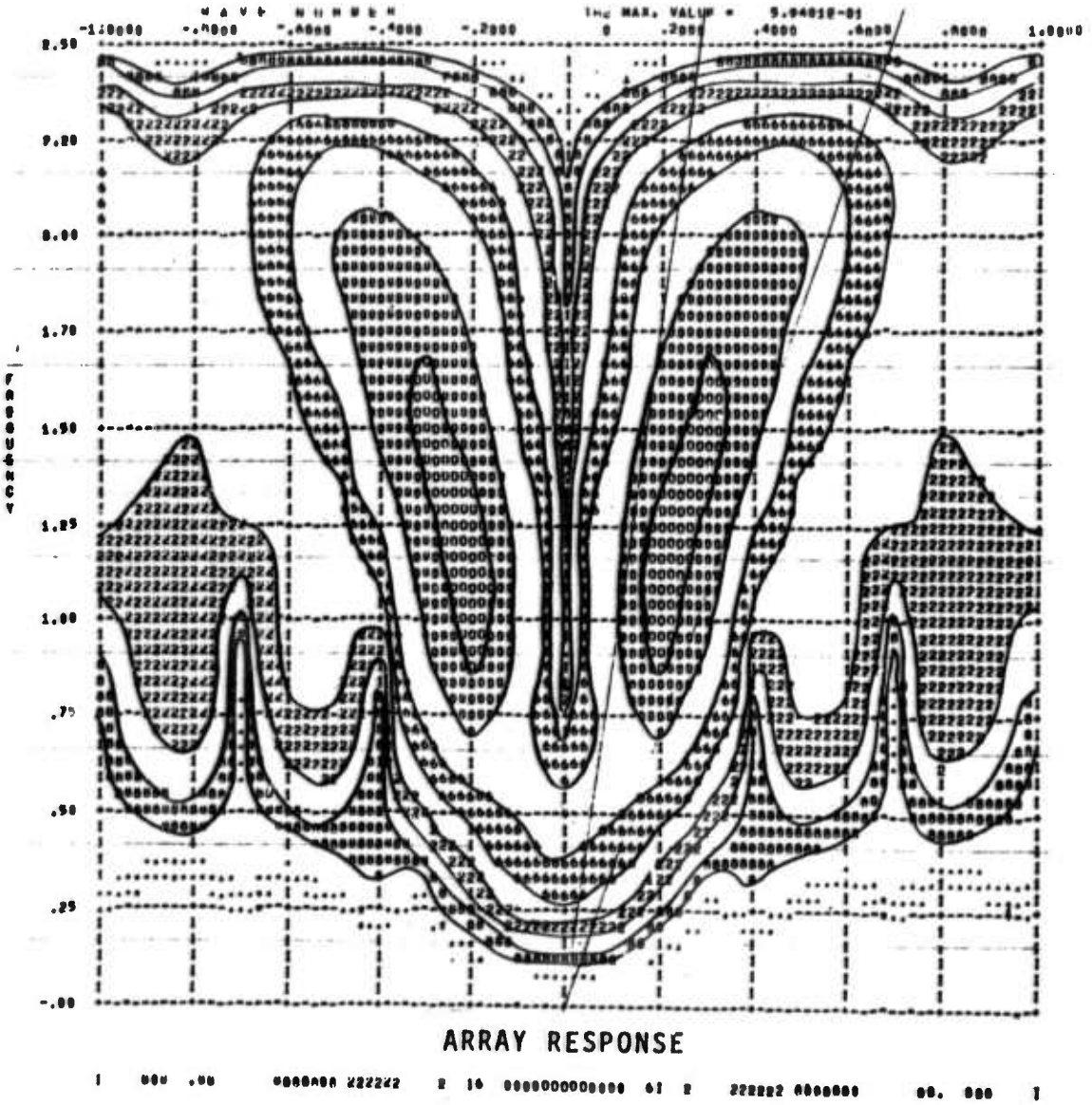
VFKOPTRN

BEIBNROHAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 400 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
Du1	1.00	.300
Du2	1.00	.900
Du3	1.00	1.500
Du4	1.00	2.100
Du5	1.00	2.700
Du6	1.00	3.300



ARRAY RESPONSE

Figure 10. Fan Filter

VFKOPTRM

SEISMOGRAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 400 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH	UP HOLE TIME FOR 6 CHANNEL
DW1	1.00	.200	.05
DW2	1.00	.900	.15
DW3	1.00	1.500	.25
DW4	1.00	2.100	.35
DW5	1.00	2.700	.45
DW6	1.00	3.300	.55

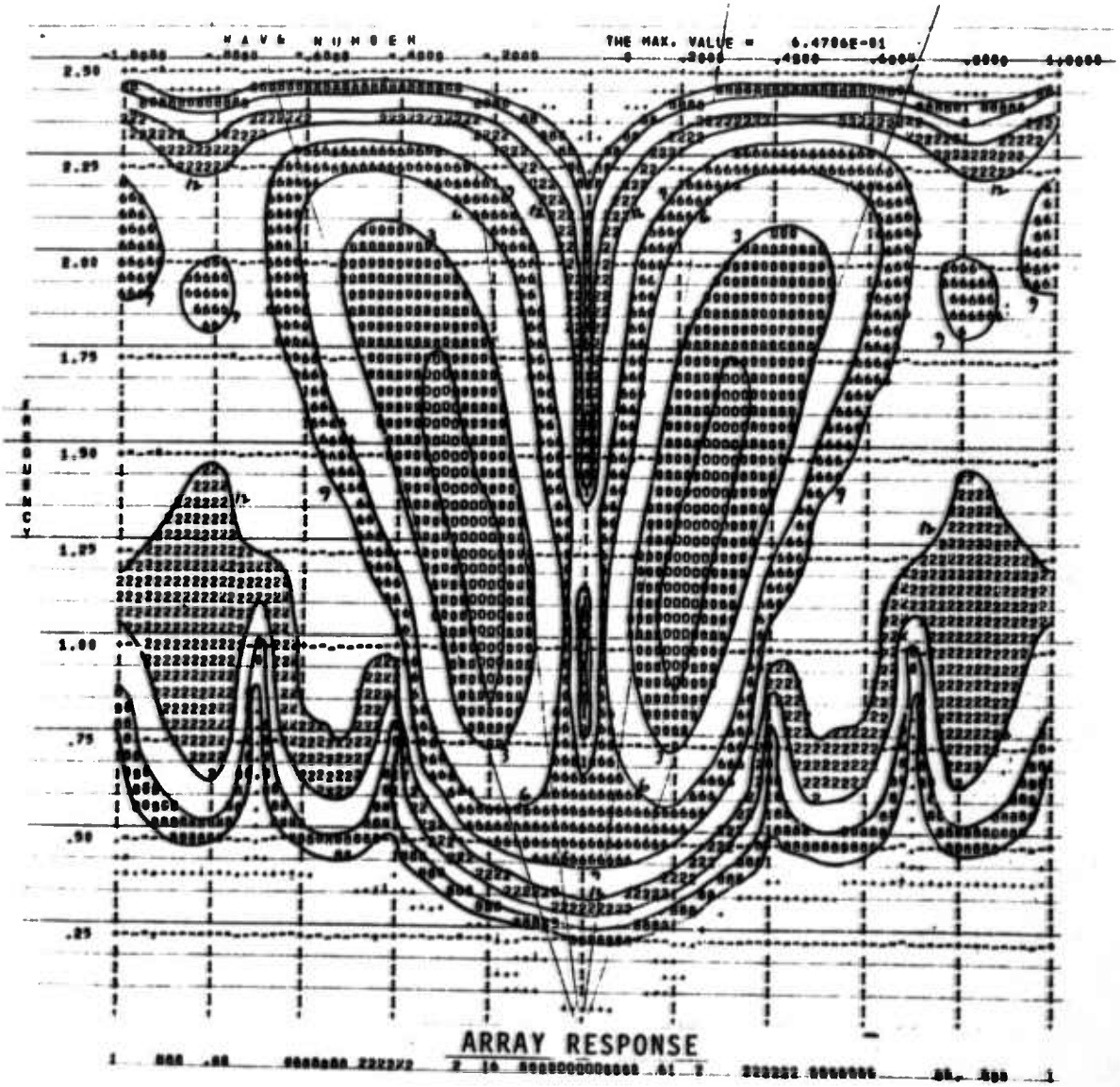


Figure 11. Fan Filter

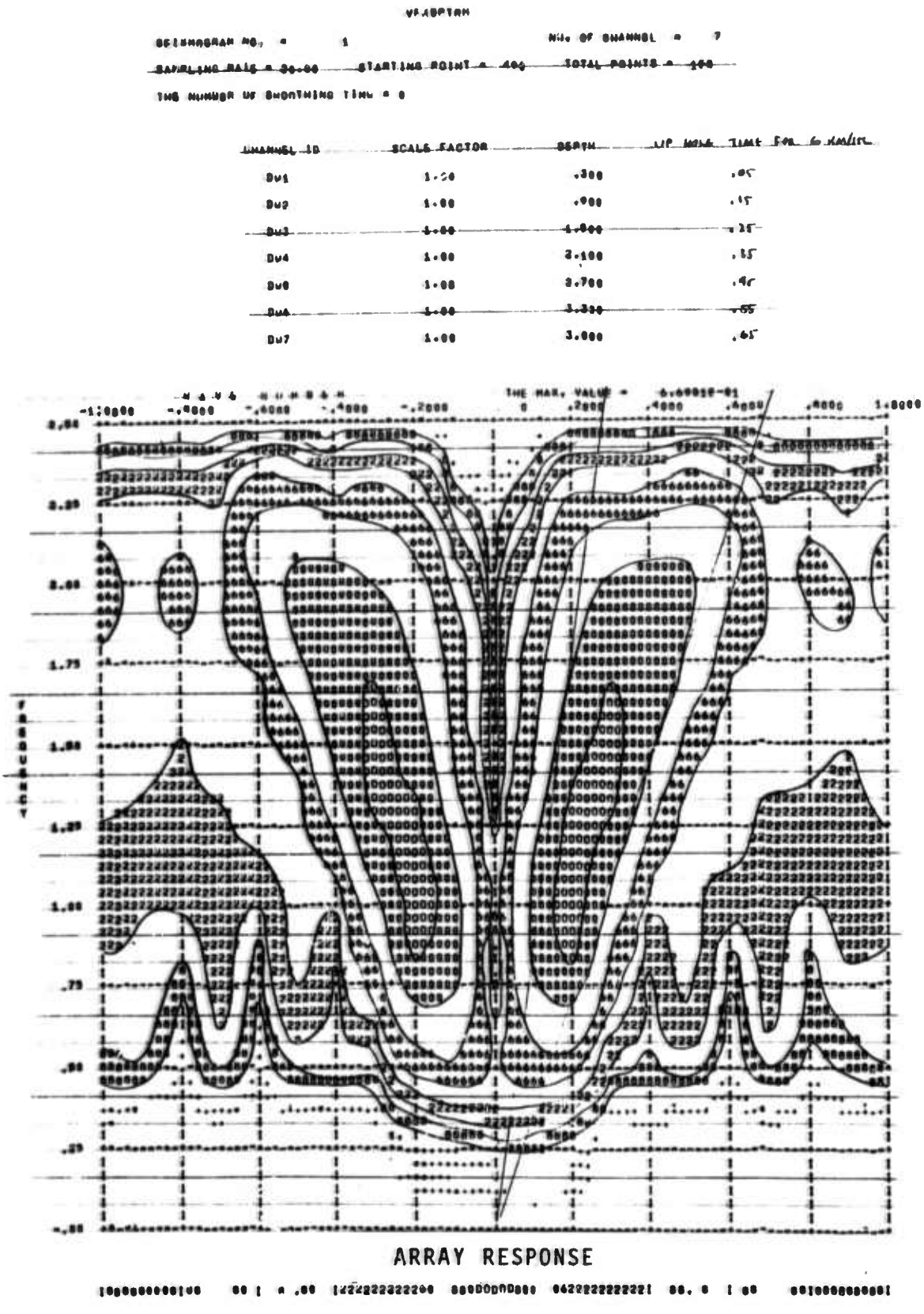


Figure 12. Fan Filter

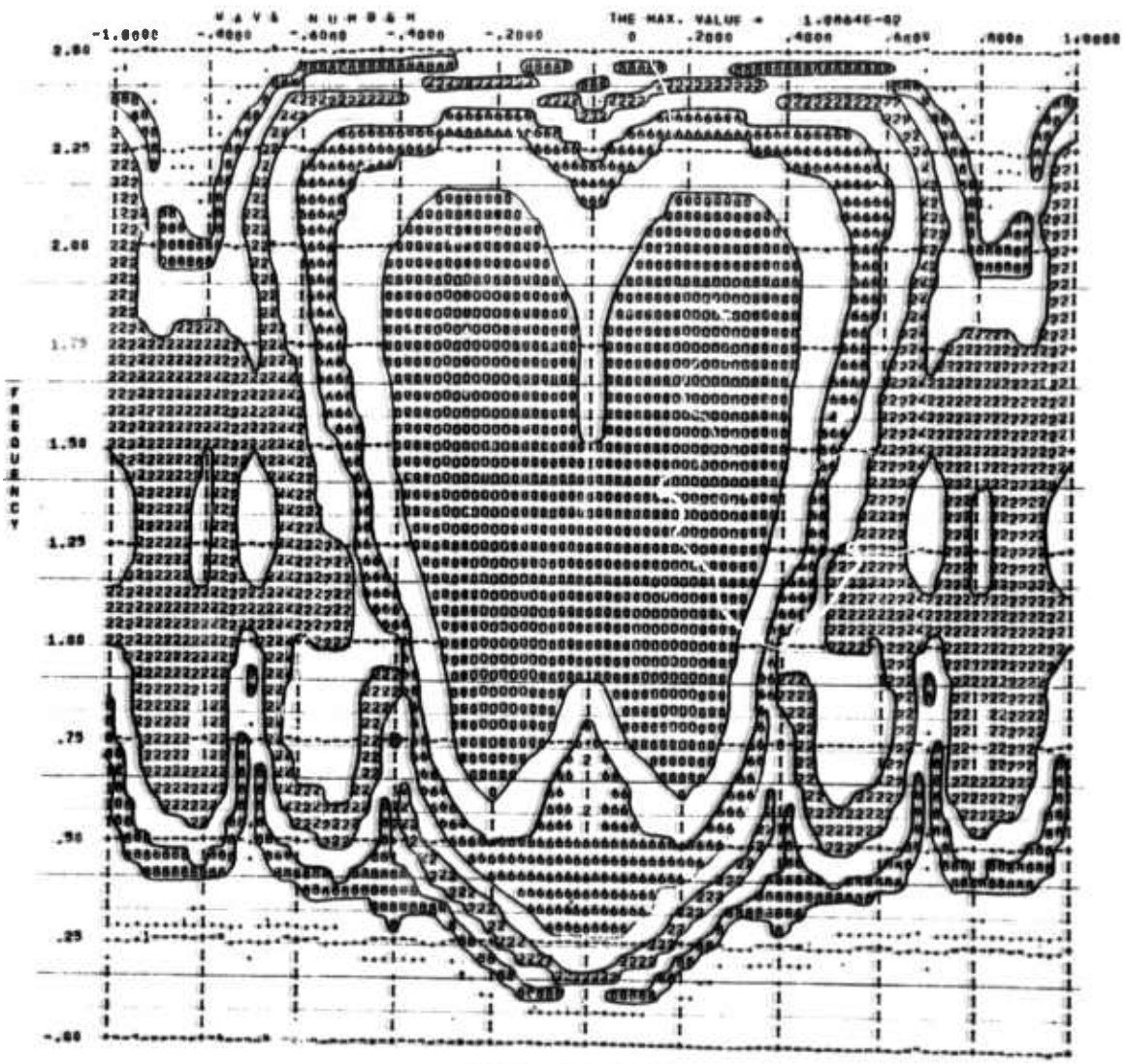
VFKDPTH

SEISMOGRAM NO. = 1 NO. OF CHANNEL = 6

SAMPLING RATE = 20.00 STARTING POINT = 836 TOTAL POINTS = 1024

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	DEPTH
VP	1.00	.900
V3	1.00	1.500
V4	1.00	2.100
V5	1.00	2.700
V6	1.00	3.300
V7	1.00	3.900



ARRAY RESPONSE

Figure 13. Fan Filter

VFKSPTRM

OSILOGRAM NO. = 1 NO. OF CHANNEL =

SAMPLING RATE = 20.00 STARTING POINT = 836 TOTAL POINTS = 128

THE NUMBER OF SMOOTHING TIME = 0

CHANNEL ID	SCALE FACTOR	OSETM
Vp	1.00	.000
V3	1.00	1.500
VA	1.00	2.100
V5	1.00	2.700
V6	1.00	3.300
V7	1.00	3.900

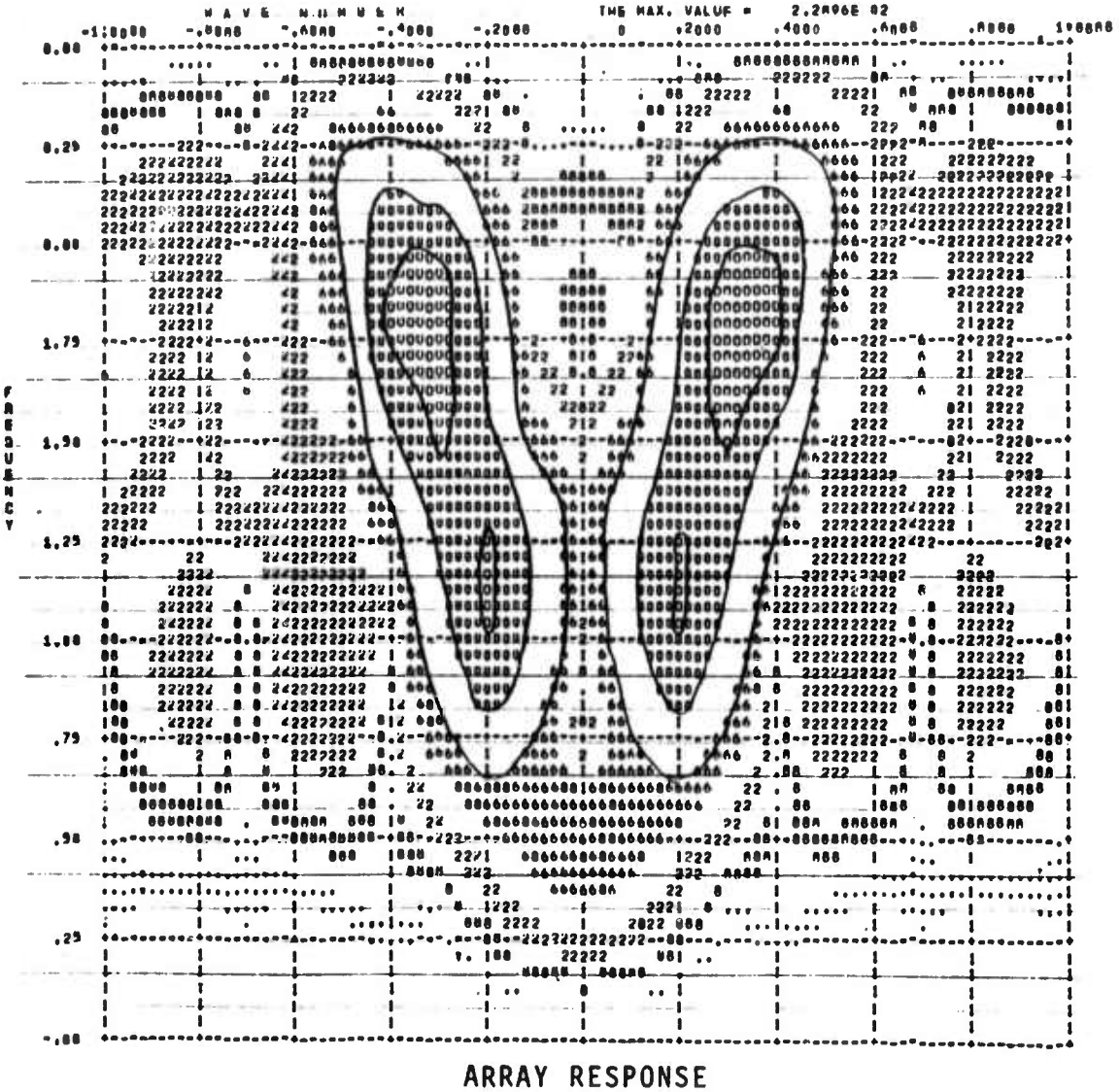


Figure 14. Fan Filter

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Several of the simplest vertical array processors were evaluated by means of frequency-wavenumber spectral analysis. The processors analyzed were beamed sum, multichannel deghost, and the fan filter. Adequate responses were obtained in the specified signal pass-band for all of the processors. Considerable differences between the processors were observed in the dead-band, especially at low wavenumbers corresponding to surface wave components in the noise. The best dead-band response was obtained for the fan filter using a spacing with uphole time between instruments of .1 seconds from the top to the bottom of the well.

14. KEY WORDS

Vertical Array Processors
Frequency-Wavenumber Spectral Analysis
Beamed Sum
Multichannel Deghost
Fan Filter

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